From Sputnik to Salyut

25 Years of the Space Age

Soviet space technology has gone a long way in 25 years—from Yuri Gagarin's 108-minute flight to stays in space of many months' duration, from isolated observations to very complex research programmes

How it Began

Konstantin Tsiolkovsky, founder of theoretical cosmonautics

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Time flies so fast that it seems the world learned the Russian word "sputnik" only a short while ago. But in fact a quarter of a century has passed since then. Space travel has become a part of our life and our way of thinking. Launching of space vehicles is no longer news. Telecasts from orbital spacecraft have become customary. Magazines publish "snapshots" of remote planets, transmitted over unimaginable distances.

Space flights have changed our mentality in some ways. They have increased our confidence in the omnipotence of human intellect and human hands. In discussing some space superproject today futurologists no longer argue about its possibility in principle, but only speak of the timing and details.

The idea of space flight was not a revelation of one man or several people. Unlike the mysteries of electricity or atomic energy it was not something concealed in the depths of matter. It seems as though it has been "in the air" since time immemorial. There have been dozens, if not hundreds, of interplanetary flight projects known to the history of mankind. But until the right time came they had all been nothing but dreams.

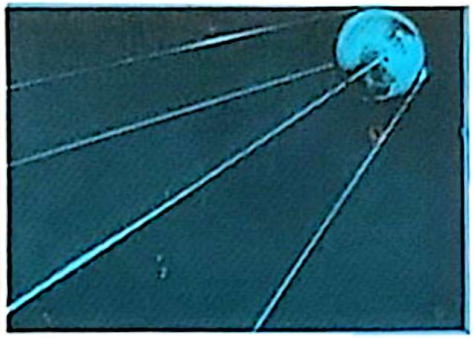
It was Konstantin Tsiolkovsky, a Russian scientist, who first specified what was needed to fly into outer space. He devoted all his life to this "mathematical operation", a life full of search, experiments, bitter disappointments and brilliant discoveries. Flight beyond the atmosphere appeared feasible only at first sight. If it could be easily done why, then, did the space age set in after the age of electricity and the age of atomic energy?

The Sputnik "Phenomenon"

After the launching of *Sputnik-1*, the first artificial earth satellite, the world "rediscovered" Russia, as it were. How did it happen that it was the Soviet Union, and not some other country, that had carried out this feat? Many answers were given, but they did not seem to explain everything. Yes, Russia was indeed the birthplace of Tsiolkovsky, the most ardent champion and populariser of cosmonautics. Yes, he had followers who were able to put fantastic ideas on the solid practical foundation. Yes, science has always enjoyed great prestige in Russia, which had long-standing traditions in aviation. But then the Americans also had their Robert Goddard, the French—their Robert

Esnault-Peltérie, and the Germans—their Hermann Oberth. And they all had technology and traditions...

Western sociologists and economists meticulously calculated the USSR's scientific and technological potential, taking into account every parameter, including steel production, output of its engineering industry, the number of libraries and researchers. There were a few curious things too: some experts counted the number of times the word "cybernetics" appeared in the names of Soviet research organisations. All these analyses produced rather trivial results. There was no *sputnik* "phenomenon" after all. But in admitting this, they also had to admit that the traditional notion about semi-backward (or "totally backward") Russia was hopelessly outdated and that in the forty years following the socialist revolution of 1917 the country had made a tremendous stride in social and industrial development. Its achievements in space travel have become a natural and logical outcome of this general advance.



The first artificial Earth satellite launched on October 4, 1957

Yuri Gagarin, No. 1 Cosmonaut

April 12, 1961—the day Yuri Gagarin made the world's first flight into outer space

On the Approaches to Outer Space

Friedrich Tsander, rocket pioneer

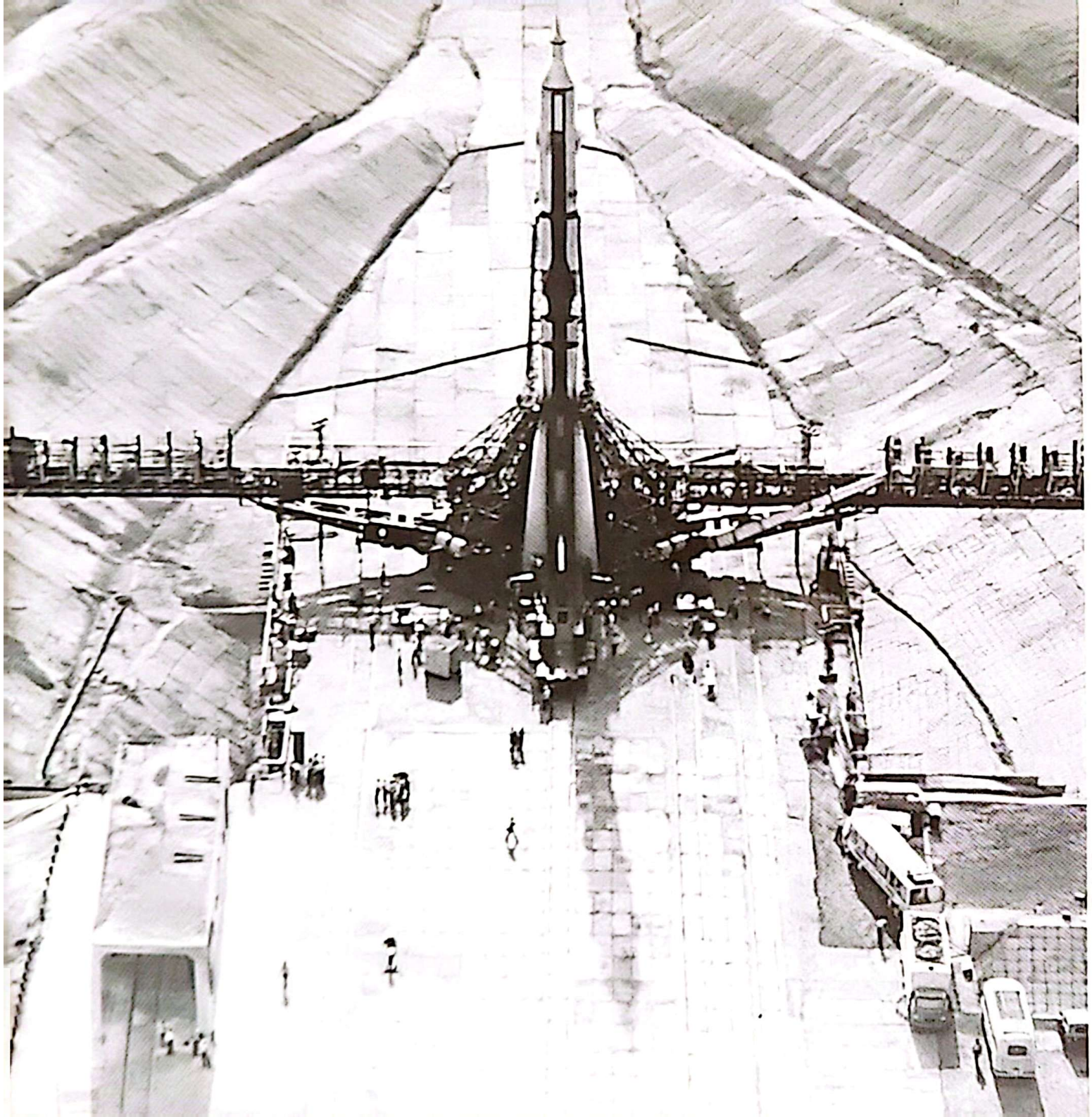
Academician Mikhail Yangel

The first theoretical studies of problems of jet propulsion began in Russia at the end of the last century. In 1903 Konstantin Tsiolkovsky published one of his most popular books entitled *The Exploration of Cosmic Space by Means of Reaction Motors*. In it he proved the possibility of space flights. But technology dictates its own laws. Mankind could break through into outer space only after mastering air travel.

The foundations for the Soviet aircraft engineering industry were laid in the 1920s-1930s, when the first big aviation research and training centres were set up.

The aircraft and engine plants and design bureaus grew rapidly. The develop-

Academician Sergei Korolyov, chief designer of space rocket systems



The USSR's breakthrough into outer space was no accident: the October 1917 Revolution opened the way to knowledge and creative endeavour for millions of people and the country developed its industrial might

It was only thanks to the social transformations brought about by the revolution that a peasant's son Yuri Gagarin became "the first citizen of the Universe"

ment of aviation is a big chapter in itself in the history of Soviet cosmonautics. It was the aviation industry that gave the space programme in its early stage most of its scientists, engineers and technicians, i.e., those who designed and built space vehicles.

Sergei Korolyov, chief designer of space rocket systems, played a distinguished role in the development and construction of *Sputnik-1*. In the beginning Korolyov followed the same path as most aircraft designers, i.e., from the glider to the aircraft. But after he met Friedrich Tsander from Riga and became acquainted with Konstantin Tsiolkovsky's ideas, the young engineer began to revise his views on aeronautics, and this literally changed his whole life.

Korolyov was fascinated by the idea of interplanetary travel, which had occupied the life of these two men. However, he realised that the idea was premature. One of Sergei Korolyov's colleagues, Mikhail Tikhonravov, had described the aeronautical concepts of the late 1920s and early 1930s as follows:

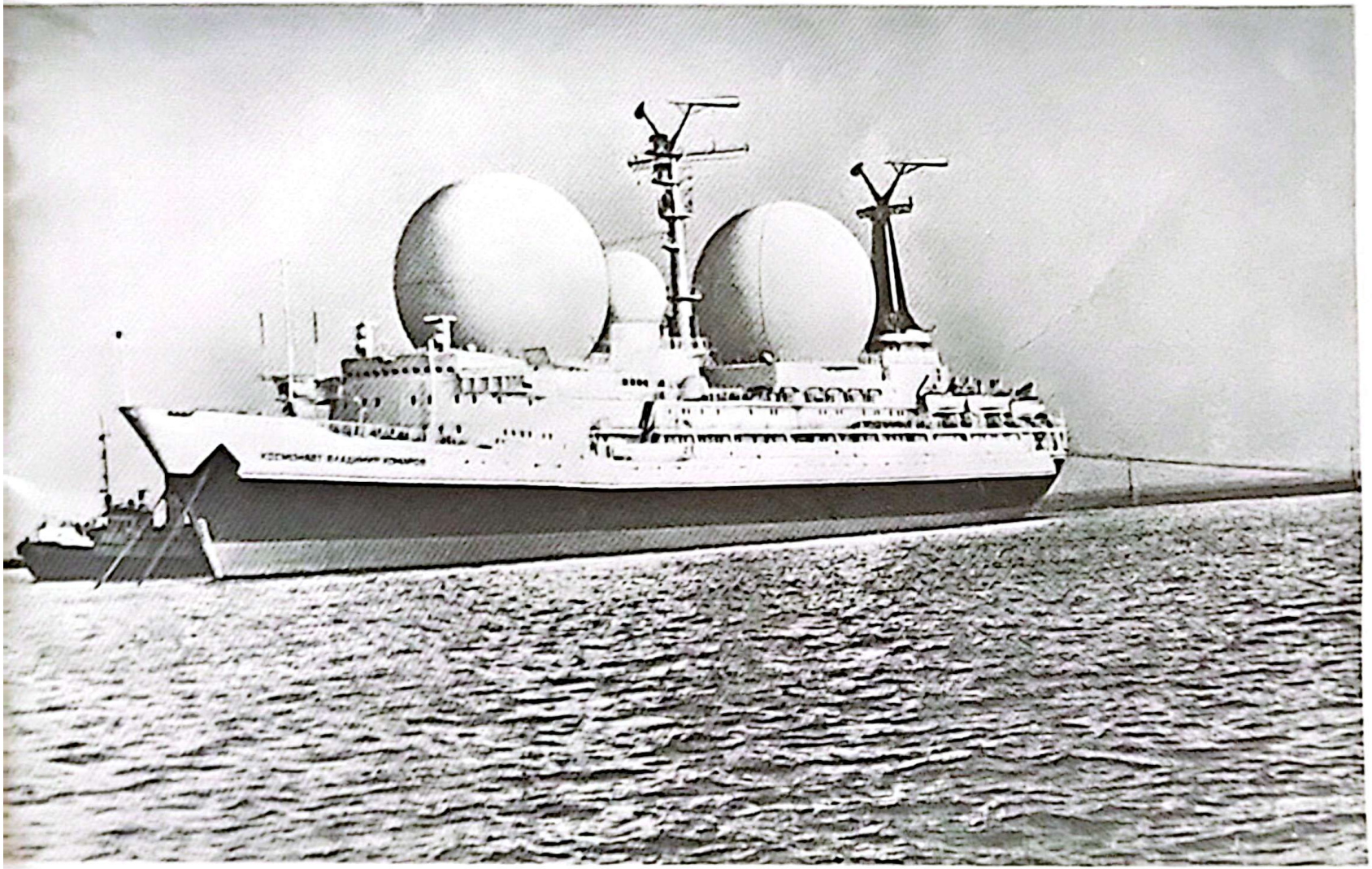
"In those years the prospects of development of aviation were already seen more clearly than before, and the limits on the use of the engine-propeller unit began to be evident, too. Several young aircraft engineers were working on ways of overcoming these limits. They concentrated their attention on jet propulsion problems, having accepted Tsiolkovsky's ideas not so much because they wished to reach Mars as soon as possible, but rather because they wanted to fly higher, faster and farther."

Korolyov regarded Friedrich Tsander's liquid-propellant jet engine as a means for achieving unprecedented speeds and altitudes. Tsander and Korolyov got together a group of enthusiasts, who were destined to develop the first small liquid-propellant rockets. At the time Korolyov's main objective was to make a rocket airplane.

Valentin Glushko, future chief designer of rocket engines, was also preoccupied with ideas of space travel. When still a student he proposed the building of an electric jet engine that would make it possible to shorten the time of flight to Mars and other planets by one half and even more.

The engine was made and tested. But it was clear that it was not powerful enough to enable the vehicle to overcome gravity. It could be used only if a great initial velocity was imparted to the rocket. Realising this, Glushko then proceeded to work on a liquid-propellant jet engine. It was this engine that in 1936 Korolyov mounted on his unmanned winged rocket. Four years later pilot Vladimir Fyodorov made the first flight in an RP-318-1 rocket airplane. Alexander Bereznyak and Alexei Isayev who worked at

Victor Bolkhovitinov's design bureau, were also attracted by the idea of an aircraft with a rocket engine. In 1941 they started to design an interceptor fighter known as the BI-1. Test pilot Georgi Bakhchivandzhi made a test flight in it in May 1942.



The *Cosmonaut Vladimir Komarov* research ship

Space Research Pioneers

A brilliant group of theoreticians and designers, such as Mstislav Keldysh, Sergei Korolyov and Valentin Glushko among many others, made a great contribution to the development of space technology and helped the Soviet Union score outstanding successes

Neither Korolyov's rocket airplane nor the BI-1 were intended to develop cosmic speeds. Tsiolkovsky's calculations showed that only a rocket "train" consisting of at least two stages could break through into space. But the work on rocket planes was not wasted. It formed a rung of a ladder that enabled aircraft engineers to ascend to the development of rockets and later to outer space.

In 1946 the design bureau under Valentin Glushko started work on developing superpowerful engines for rockets with a thrust of tens and even hundreds of tons. These were the kind of engines that were mounted on the carrier rocket which put *Sputnik-1* into orbit.

After his work on the BI-1 Alexei Isayev headed a group which later became an independent design bureau. Its engines were also widely used in cosmonautics. They powered manned spacecraft and interplanetary stations. In 1958 a team under Semyon Kosberg began the development of engines for the upper stages of launch vehicles.

As regards modern Soviet rocket manufacture, its foundations were laid during the first two post-war five-year plan periods. It was then that rocket- and engine-manufacturing plants were being built and new institutes, testing grounds and design bureaus were being set up. In the late 1940s there were 13 institutes and bureaus and 35 plants in this field. Their specialisation in the development of various highly important systems was becoming more pronounced. Nikolai Pilyugin, a Member of the USSR Academy of Sciences, became the founder of rocket control systems. By the time the space age set in he was a member of the Council of Chief Designers.

As the power and range of rockets increased the launching complexes began to acquire ever greater importance. Vladimir Barmin, a Member of the USSR Academy of Sciences, made a great contribution to their development. In February 1955 it was decided to build the country's main launching pad—the Baikonur Cosmodrome—now known to the whole world.

Anyone who knows something about cosmonautics "from the inside" is aware that it is not only rocketry and that much of it involves mathematics. Every design begins with mathematics, and it remains indispensable when the designed object undergoes its innumerable tests and then finally breaks through into outer space. Coordination of elaborate space programmes is inconceivable without mathematics insti-

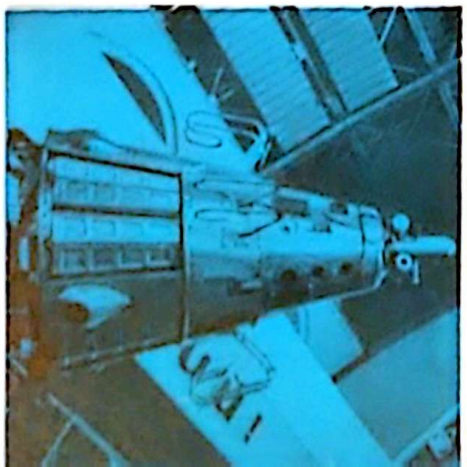
tutes and computing centres. It is hardly surprising, therefore, that the man who directed this vast effort was a brilliant mathematician. Mstislav Keldysh, known as the "chief theoretician of cosmonautics", distinguished himself when still a young man as the author of outstanding mathematical research and also of applied works in the field of aviation. In 1946, when Mstislav Keldysh was only 35, he was elected a Member of the USSR Academy of Sciences. Research in two major problems of our time—nuclear power engineering and cosmonautics—became his lifework.

Academician Valentin Glushko, designer of rocket engines

Academician Mstislav Keldysh, chief theoretician of space technology

The Chief Designer of *Sputnik-1*

Exploration of outer space began with vehicles made under Sergei Korolyov's guidance



In the first two postwar decades Sergei Korolyov was beyond doubt the leading expert in rocket manufacturing and the development of space vehicles. The first Soviet R-1 guided rocket with a range of 300 kilometres was launched in 1948. A year later Korolyov's team designed on its basis the first geophysical rocket which was followed by more powerful models. This ultimately led to the achievement of cosmic speeds.

It is impossible not to admire Korolyov's courage and daring both as scientist and citizen. In 1954 he addressed a letter to the USSR Council of Ministers, which contained this statement: "Current work on the development of a new rocket... permits us to speak of the possibility of building an artificial Earth satellite within the next few years." Long before the rocket was ready work was started on designing three models of a satellite. In April 1956 (an important date to remember!), i.e., a year and a half before *Sputnik-1* was launched, Korolyov brought up the question of a manned space flight.

Another characteristic of Korolyov merits attention. A rocket which became known as the "vehicle of the century" was developed under Korolyov's guidance. Over a period of many years its technical characteristics were second to none. He could well have confined his efforts to improving its design. But Korolyov was known for the breadth of his creative endeavour. The manned spaceships *Vostok, Voskhod* and *Soyuz*, the *Molniya* communications satellite, and the first interplanetary probes sent to the Moon, Mars and Venus were all developed under

Korolyov's direction. The first sketches of orbital stations were made when he was still alive.

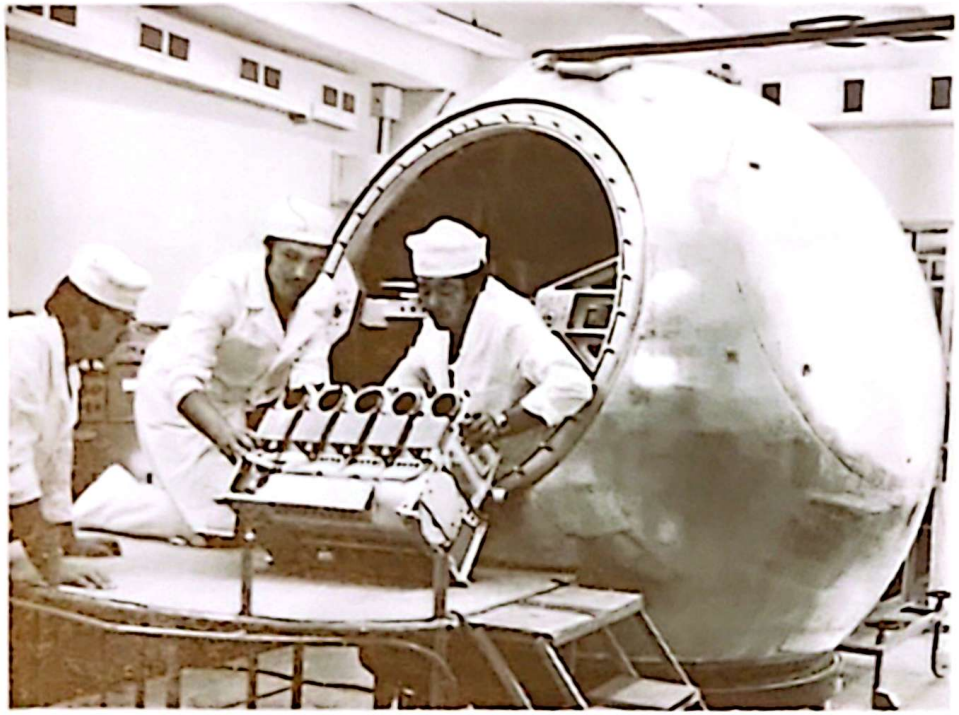
One now speaks of scientists and researchers of the "Korolyov school", and this is understandable. Some who worked in Korolyov's team later headed independent design bureaus. One of them was Mikhail Yangel, a Member of the USSR Academy of Sciences, who played a major role in the development of rockets and numerous space vehicles—the *Kosmos* satellites. Another was Georgy Babakin, a Corresponding Member of the USSR Academy of Sciences, who carried on Korolyov's work in the field of designing automatic interplanetary probes.

When work on *Sputnik-1* was started in 1956, the rocket that was to put it into orbit did not yet exist. But Korolyov was confident that it would soon be developed, and he was right. In August 1957 the Soviet Union announced that it had developed the world's first intercontinental rocket. It formed the basis for the building of a two-stage *Sputnik* rocket which launched into space the world's first artificial Earth satellite—

Laika, the first space traveller

Sputnik-1—on October 4, 1957. It weighed 83.6 kilogrammes. Within a month another space vehicle, weighing 500 kilogrammes, was orbited. It carried the first space passenger—a dog named Laika. In May 1958 a space laboratory weighing over 1,300 kilogrammes began to function in near-Earth space.

Space Scouts



Preparing a *Kosmos* satellite for launching

In March 1962 a *Kosmos-1* satellite was launched. It was the first of the most numerous series of space vehicles. The number of *Kosmos* satellites in orbit exceeds 1,300. With the advent of these vehicles space exploration and work on new technical solutions were placed on an industrial basis. The launching of the first few vehicles showed that it was possible considerably to cut the time needed to introduce new space vehicles in practice and reduce their cost provided the service systems were standardised and satellites put into serial production.

On the basis of the *Kosmos* programme scientists worked out principles for a future long-range space communications system. The *Kosmos* satellites have made it possible to obtain the first data on the propagation of radiowaves in near-Earth space, appraise the performance of onboard equipment and determine the most advantageous orbital parameters.

Experiments conducted on board the *Kosmos* satellites preceded the development of weather and nature research satellites. *Kosmos* satellites have also made it possible to carry out a magnetic survey of practically the entire surface of the Earth. The information thus obtained is vital for mineral prospecting and for sea and air navigation.

As the duration of manned flights increased it became important to understand how space affected living organisms and how to improve the life support systems. Many of these problems were investigated with the help of *Kosmos* satellites.

Vehicles of a similar type have enabled Soviet scientists for the first time to "place" telescopes beyond the Earth's atmosphere and conduct observations in the entire electromagnetic wave spectrum from orbit over a prolonged period of time.

Kosmos-1000, launched in 1978, was the first orbital beacon by which

ships at sea can determine their position in any point of the World Ocean with a high degree of accuracy regardless of weather conditions. It forms a part of a satellite navigational aid system.

Kosmos satellites have also assumed the function of "test bench" for many types of space vehicles. For instance, separate assemblies of the *Lunokhod* moon rover were tested on board *Kosmos* satellites, and so was automatic docking of spacecraft in orbit. These experiments paved the way for orbital stations.

The experience gained in conducting experiments on board *Kosmos* satellites formed the basis of the *Interkosmos* programme, in which ten socialist countries are taking part.

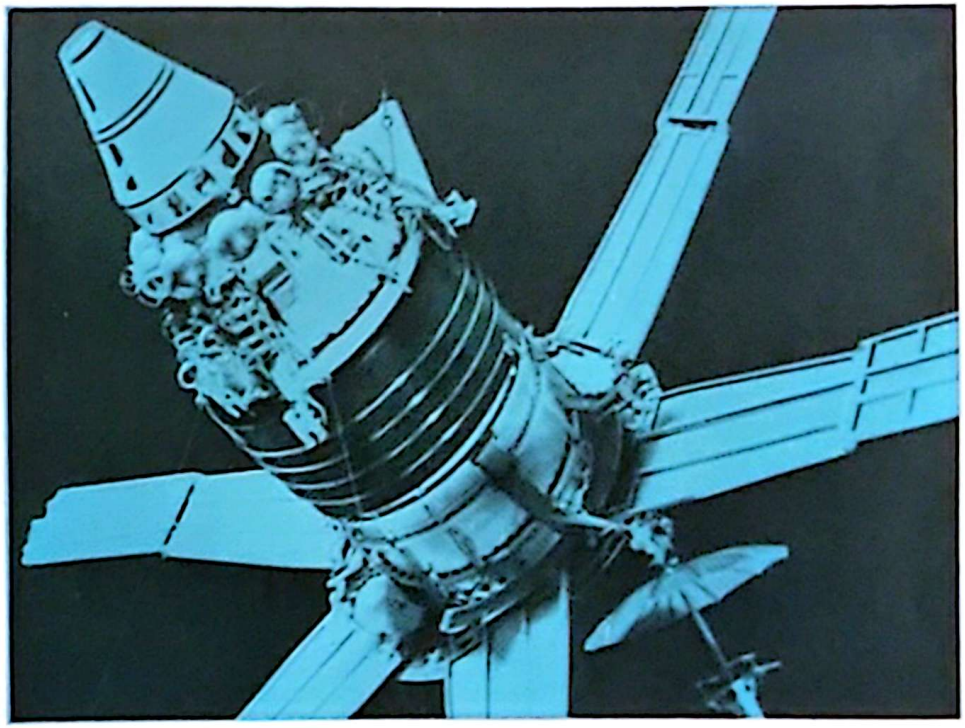
Of course, many of the experiments are of a specific nature whose requirements cannot be met by spacecraft of one type only. Scientists have therefore developed several modified versions of the *Kosmos* satellites.

From *Molniya* to *Gorizont* Satellites

The first *Molniya* communications satellite was put into orbit in 1965. Soon after that a special network of ground-based stations, known as the *Orbita* system, was built to use the communications satellites. The putting into service of this system marked the beginning of the use of spacecraft for the needs of the national economy on a mass scale.

Molniya satellites were put into elliptical orbits. The world's first relay stations (with an output of 40 watts for television and of 14 watts for telephone communications) were developed for them. At the time this was an impressive achievement. Suffice it to say that in those days the maximum output of equipment on board similar US satellites was only 12 watts.

A typical *Orbita* station is a circular ferroconcrete building with a 12-metre tracking aerial. The aerial is designed to function normally at wind velocities of

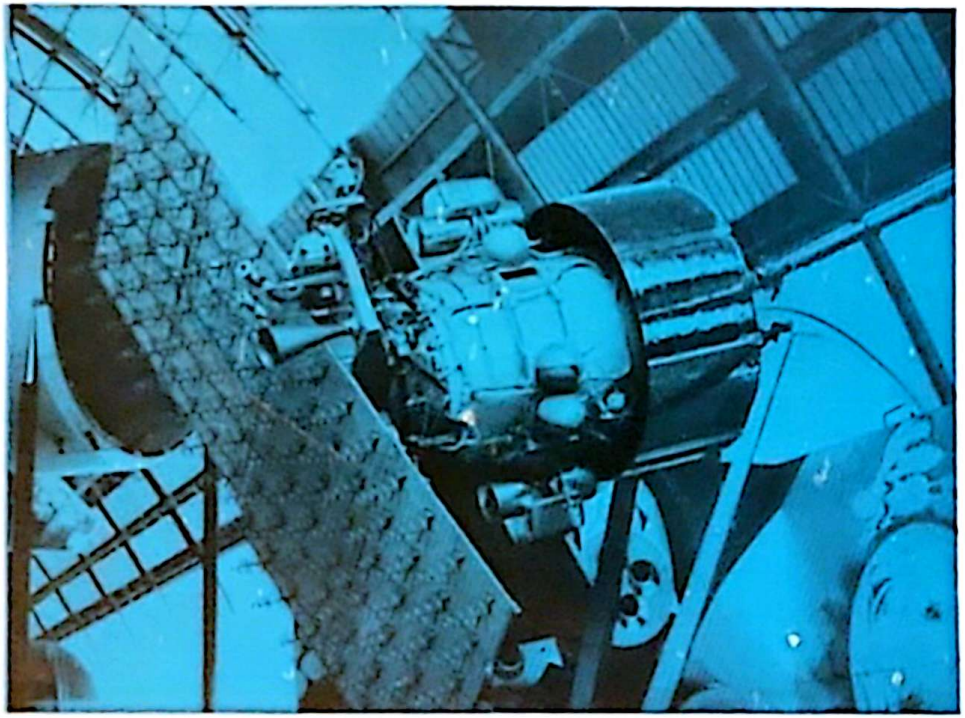


Molniya-1
communications satellite

up to 25 metres per second and at temperatures ranging from +50 to —50° C. This means that it can operate efficiently in regions having a very cold or a very hot climate. In subsequent years such stations were built in practically every city and big town in Siberia, the Far North and the Soviet Far East. Today there are 90 of them altogether. Researchers are currently working on new and more economical devices for relaying TV programmes to the remotest corners of the USSR.

The *Ekran* system meets these requirements. The first *Ekran* satellite was launched on October 26, 1976. The *Ekran's* field of view covers an area of nearly nine million square kilometres, or 40 per cent of the territory of the USSR. The high-power transmitter on board the satellite makes it possible to use rather cheap aerials of simple design on the Earth. The *Ekran* system is widely used for servicing both big inhabited localities and small settlements as well as geological prospecting parties and oil extracting and timber cutting teams. The wavelength range of the *Ekran* system is also used for ground telecasts in some of the

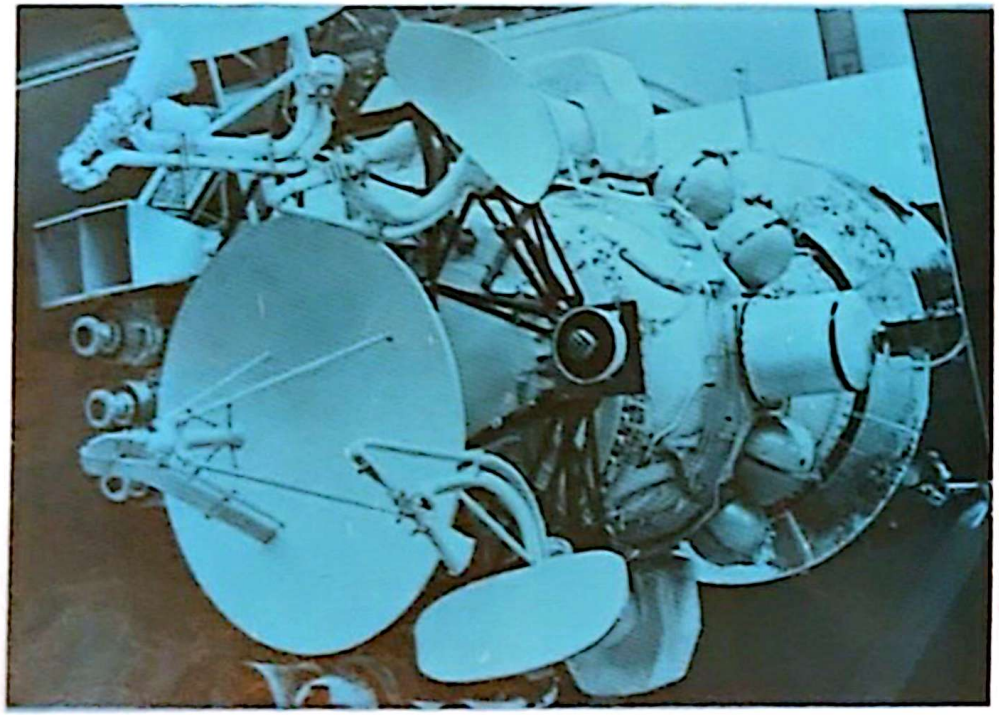
Mars mobile station for TV communications



Ekran communications satellite

Superlong-range communications, meteorology, navigation and nature studies are now inconceivable without space vehicles. About 600 industrial enterprises and research organisations in the USSR are using information received from space

Orbita communications station



Gorizont communications satellite

countries bordering on the USSR. To prevent interference with reception of TV programmes another system—the *Moskva*—is functioning in a number of areas of the Ural Region, Soviet Central Asia and the Soviet Far East. These systems make it possible to bring TV programmes practically to every part of the USSR.

The *Moskva* system uses satellites of the new *Gorizont* series. They are outfitted with a 40-watt transmitter whose signals can be picked up by ground-based parabolic antennas with a diameter of 2.5 metres. Relatively low-cost receiver stations have been developed that can service practically any inhabited locality in the country.

The USSR has put into service satellites for radio broadcasting. Some radio programmes are prepared in Moscow, and later distributed throughout the country. Such programmes are transmitted with account taken of the local time zones, just like the TV programmes. This requires an extensive network of communications channels. To create such a network with ground-based facilities alone is impossible.

Copies of central newspapers are transmitted on a growing scale through communications channels. The USSR has about 50 centres for the reproduction of central newspapers. In addition to ground channels, space communications channels are used for photoelectric transmission of newspaper pages. The first experiments were conducted in 1968. Shortly after that a Moscow-Khabarovsk satellite communications line was commissioned. Systems have now been developed for transmission of newspaper page images together with TV and radio programmes.

Meteor Satellites and Nature Research from Space

The decision on developing weather satellites was taken in 1962. Five years later weather satellites of the *Meteor* series were orbited. Together with ground-based facilities the *Meteors* first formed an experimental and then an operational system that has been effectively functioning for 15 years now. Information supplied by these satellites helps the USSR save from 500 to 700 million roubles a year.

When the idea of building weather satellites was first considered Sergei Korolyov, Mstislav Keldysh and Mikhail Yangel vigorously supported it and arranged for several research and development organisations to work on the project. A team of electrical en-

Sergei Korolyov, Mstislav Keldysh and Mikhail Yangel strongly supported the idea of building weather satellites. Today these vehicles save the Soviet economy about 500-700 million roubles a year

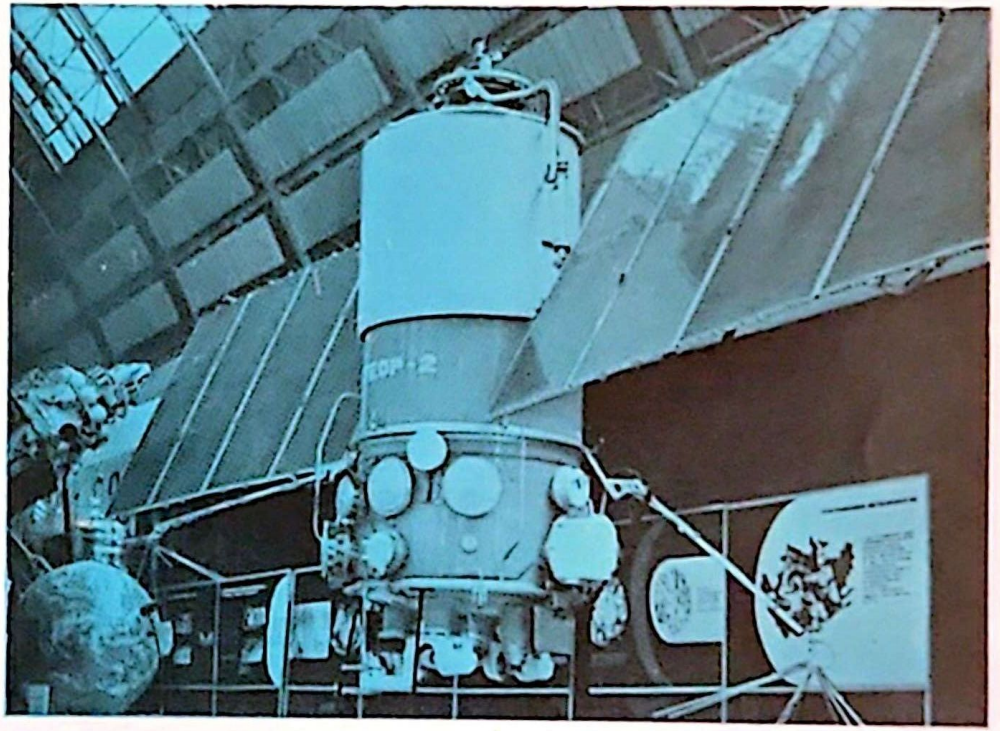
gineers headed by Andronik Iosifyan, a Member of the Armenian Academy of Sciences, played the leading role in this work.

Specialists had to put much effort into developing new systems of attitude control and stabilisation, power supply and temperature control. In many ways weather satellites differ from other spacecraft. Their TV, infrared and other devices scanning the Earth must always be pointed strictly downward along the local vertical. This means that the attitude control and stabilisation system must function constantly. The compressed gas nozzles or liquid-propellant jet engines installed on board the early space vehicles were unsuitable here because of their high fuel consumption. Preference was therefore given to so-called flywheel or gyroscopic systems. By regulating the speed of rotation of the flywheel or gyroscope it is possible to turn the space vehicle and retain it in the desired position. The systems are rotated by electric motors which are dependent on electric power supply. A storage battery would not last long in such a case. The motors could be recharged only with the help of solar panels. It was decided to use such systems which were tried out, for the first time in world engineering practice, on board *Kosmos-14* and *Kosmos-23* satellites.

The Earth from outer space

In the beginning, the service life of a weather satellite was determined by the capacity of the power supply system and did not exceed six months. Subsequently the main performance characteristics of the power supply systems were increased almost fourfold.

There is yet another onboard system of the *Meteor* satellite which was later widely used in many other space vehicles including the *Salyut* orbital stations. This is a special attitude control system for solar panels. A solar battery generates the greatest amount of energy when the sun rays fall on the surface of the panel perpendicularly. If the solar panels are rigidly secured in one position, this condition can be met only on very short sections of the



Meteor-2 weather satellite

orbit. To overcome the difficulty automatic devices which kept the solar panel surfaces constantly trained perpendicularly to the sun rays were developed for the *Meteors*. Magnetic motors were tested on board weather satellites. Their electromagnetic coils interacting with the Earth's magnetic field built up a control moment which influenced the body of the spacecraft. In December 1971, plasma engines were tried out for the first time.

Many states today are interested in studying the World Ocean by satellites, whose number is growing every year

Many of these systems are now used in satellites for nature research. However, these space vehicles are essentially different from weather satellites. The instruments on board weather satellites which observe vast areas have a relatively low resolving power measured in kilometres. To carry out nature research the instruments need a "sharper eye", i.e., their resolving power must be measured in tens of metres. The onboard control systems must have a greater angular accuracy, too. Nature research satellites have to handle much more information than weather satellites, and the information obtained is also more varied.

But despite this, the problems of nature research from outer space are being successfully solved. Many vital elements of nature research satellite system are already functioning. Scientists believe that the building of the system will be completed in the 1980s.

A network of regional information centres, including Moscow, Novosibirsk and Khabarovsk, for receiving and processing data, and also of sectoral centres for thematic processing of information is being set up. Provision is being made for direct transmission of information to simplified self-contained centres of the USSR Weather Service and also to many stations outside the USSR.

Satellites and the World Ocean

Much attention is now being paid to sea and ocean research with the help of space vehicles. The main objects of observation are sea and oceanic currents.The first ocean research satellites were *Kosmos-1076* and *Kosmos-1151* and *Interkosmos-20* and *Interkosmos-21*.

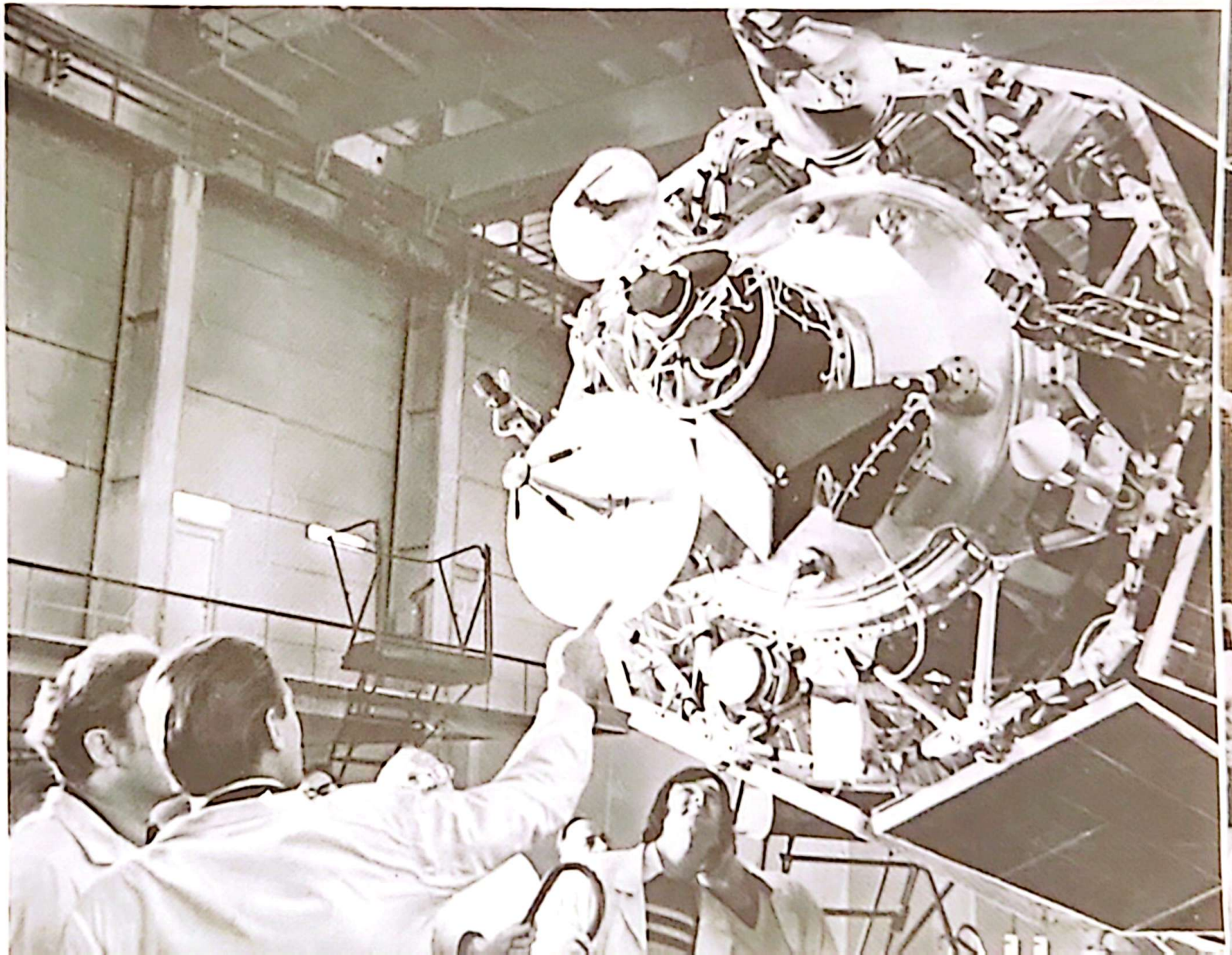
Shipping has also been benefited by satellites. Soviet scientists are now working on a system of satellite navigational aids, known as *Tsikada*, which is based on satellites of the *Kosmos-1000* type. Orbital beacons make it possible to locate the position of sea vessels in any point in the world with an accuracy of 80-100 metres.

Several beacon satellites can do the work of large numbers of ground refer-

ence points, improve the accuracy of navigational measurements and thus make navigation more economical and safer.

It is these considerations that have prompted 29 states to pool their efforts in the development of a global marine communications and navigational system. Six geostationary satellites over the Pacific, Indian and Atlantic oceans will raise the safety of navigation in a zone from 70° north to 70° south. In addition, Soviet, US, French and Canadian scientists are working on an experimental search and rescue system to save crews of ships and aircraft in distress. In the event of an accident a special beacon on board a ship or airplane will transmit information by radio on the position of the ship or aircraft, the nature of the accident and other information. The satellite within the range of radio visibility will send the information to all ships and aircraft nearby and also to coastal rescue services.

Interkosmos-20 satellite



The *Salyut* Takes Over

The development of satellite systems is impossible without the participation of cosmonauts. In the beginning the main role was played here by manned spaceships *Vostok*, *Voskhod* and *Soyuz* and at present—by the *Salyut* orbital stations.

Soviet-Czechoslovak crew conducting medical observations on board the *Salyut-6* station. Left to right: Georgi Grechko (USSR), Vladimir Remek (Czechoslovakia) and Alexei Gubarev (USSR)

The *Soyuz* spaceships have been in service for 15 years. They have been used for prolonged flights, astronomical observations and nature research, and for carrying out the first technological experiments. When two *Soyuz* spaceships docked in space in 1969, they formed the world's first experimental orbital station weighing close to 13 tons.

In the 1970s the main job of the *Soyuz* spaceships was transportation of relief crews to orbital stations. The *Soyuz* served as the basis for the unmanned cargo ship *Progress*. In 1979, after undergoing modernisation, the *Soyuz* manned spaceship virtually became a new ship—*Soyuz-T*. However, it was the *Salyut* stations that came to play the leading role in space exploration.

The first *Salyut* station was put into orbit in 1971. Later four more were launched.

But the real record holder of the *Salyut* series was the sixth station. What distinguishes it from its predecessors is that it has two docking units which enable the main crew to carry on their work while at the same time receiving "visiting" space expeditions. The *Progress* automatic cargo ships ensure a steady supply of fuel, food, air, scientific equipment and replacement parts. This has considerably improved the performance of this orbital laboratory. Cosmonauts stayed on board the station for 676 days. During this time five main crews and 11 "visiting" crews worked on board it; they consisted of a total of 27 cosmonauts including eight cosmonauts from fraternal socialist countries. The crews carried out over 1,600 experiments for the benefit of science and the national economy.

Soviet-Polish crew—Pyotr Klimuk and Miroslaw Hermaszewski

Valeri Bykovsky (right) and Sigmund Jähn of the German Democratic Republic in training

Altogether 27 cosmonauts, including eight from fraternal socialist countries, have worked on board the *Salyut* orbital station

Nikolai Rukavishnikov (USSR) and Georgi Ivanov (Bulgaria)

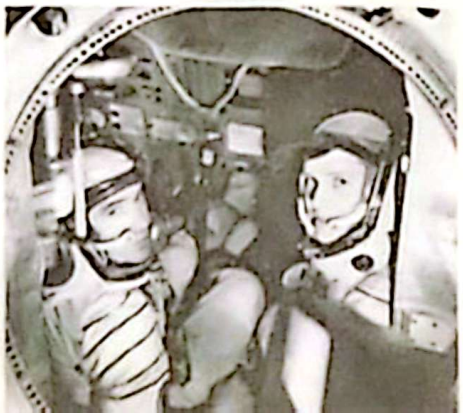
Outer Space at the Service of Earth

Viktor Gorbatko (USSR) and Pham Tuan (Vietnam)

Soviet-Hungarian crew—Valeri Kubasov (left) and Bertalan Farkas

Soviet cosmonaut Yuri Romanenko and Arnaldo Tamayo of Cuba

Soviet-Mongolian crew—Vladimir Dzhanibekov and Zhugderdemidiyn Gurragcha



Leonid Popov (USSR) and Dumitru Prunariu (Romania)

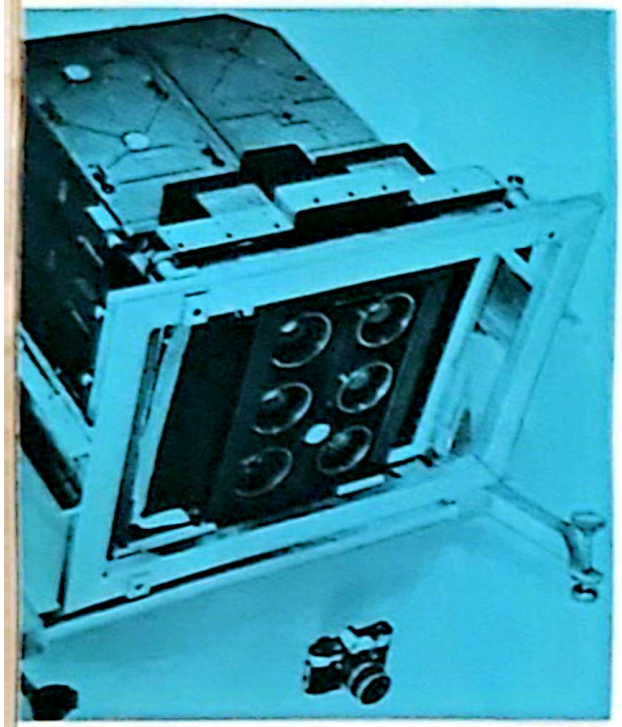
Science fiction of the pre-space age had one interesting feature: rockets and spaceships were depicted in every possible capacity except that of vehicles helping to meet purely "earthly" needs. With rare exceptions the same trend existed in scientific literature. For instance, among possible uses of rockets (except manned flights, of course) Sergei Korolyov mentioned only one—express delivery of mail from one continent to another. Life, however, has proved itself, in this case, more imaginative than wildest fantasies.

Rockets have not been used for mail delivery. But they are putting into orbit satellites that bring direct benefits to the national economy. And Sergei Ko-

Nature studies on board a research aircraft

Studying photographs taken in space

MKF-6 multispectral camera



Testing the MKF-6 camera in an airplane

rolyov was one of the first to develop such satellites. In some sectors of the economy space vehicles have proved to be highly productive. Here are only a few examples.

In the USSR farmland occupies an area of over 660 million hectares. About one-third of it is ploughland. Maps showing the use of land change quickly, becoming obsolete every five years. To compile new ones is costly and time-consuming. It seems an insoluble problem. And it was space science that solved it.

The *Salyut-6* station carried on board two instruments as the main land surveying devices: the Soviet-made KATE-140 wide-scan topographic camera and the MKF-6M multispectral camera manufactured at the Karl Zeiss Jena plant (GDR).

The KATE-140 camera scans a strip of the Earth's surface 450 kilometres wide. Every picture covers an area of 200,000 square kilometres. In four to five minutes the cosmonauts

photographed an area which would take from 18 to 24 months to chart with conventional aerial photography. The MKF-6M camera has been used to take tens of thousands of photographs of the Earth's surface and the World Ocean.

Space vehicles make it possible to "penetrate" into the remotest areas and thus help to put their resources to economic use. The *Salyut-6* station began to explore the forests of Siberia and the Soviet Far East, and the steppes and semi-deserts of the southern part of the country where there are areas that could be used for pasture livestock-breeding. The space crews have made a notable contribution to minerals prospecting, namely for oil, gas and ores. They have also effectively helped fishing vessels in their search for new fishing grounds.

Technology, Pharmaceutics ... What Next?

There is little doubt that with time more satellites performing economic tasks, including even whole automated enterprises for the manufacture of semiconducting crystals, metallised glass and composite materials, will be orbited. *Salyut-6* and some of the high-altitude rockets have recently been used for making numerous products that are far superior in quality to similar products made on Earth. Many of them are now being used in infrared devices, micro- and radioelectronics, optics and electrical engineering. The demand for such materials is relatively low, but the manufacturing costs in conventional conditions on Earth are very high. It is believed that in the not too distant future specialised orbital modules with production equipment will be developed, which will grow crystals either in accordance with special programme controlled processes or on commands given from the Earth. The products will be delivered to Earth by automatic vehicles or by manned spaceships. The *Kosmos-1267* satellite currently on a joint flight with the *Salyut-6* orbital station can be regarded as a prototype of such a module. Besides electronic and optical works, pharmaceutical departments making unique medical preparations may also appear in space in the near future. Results obtained in this sphere thus far are highly encouraging.

The time is not far off when there will be space factories and plants making semiconductors, optical devices and medicines

Cooperation in Space

Ten socialist countries—Bulgaria, Cuba, Czechoslovakia, the German Democratic Republic, Hungary, Mongolia, Poland, Romania, the USSR and Vietnam—are cooperating in the *Interkosmos* programme which has the launching of 22 satellites and ten high-altitude geophysical rockets and several manned space flights by international crews to its credit

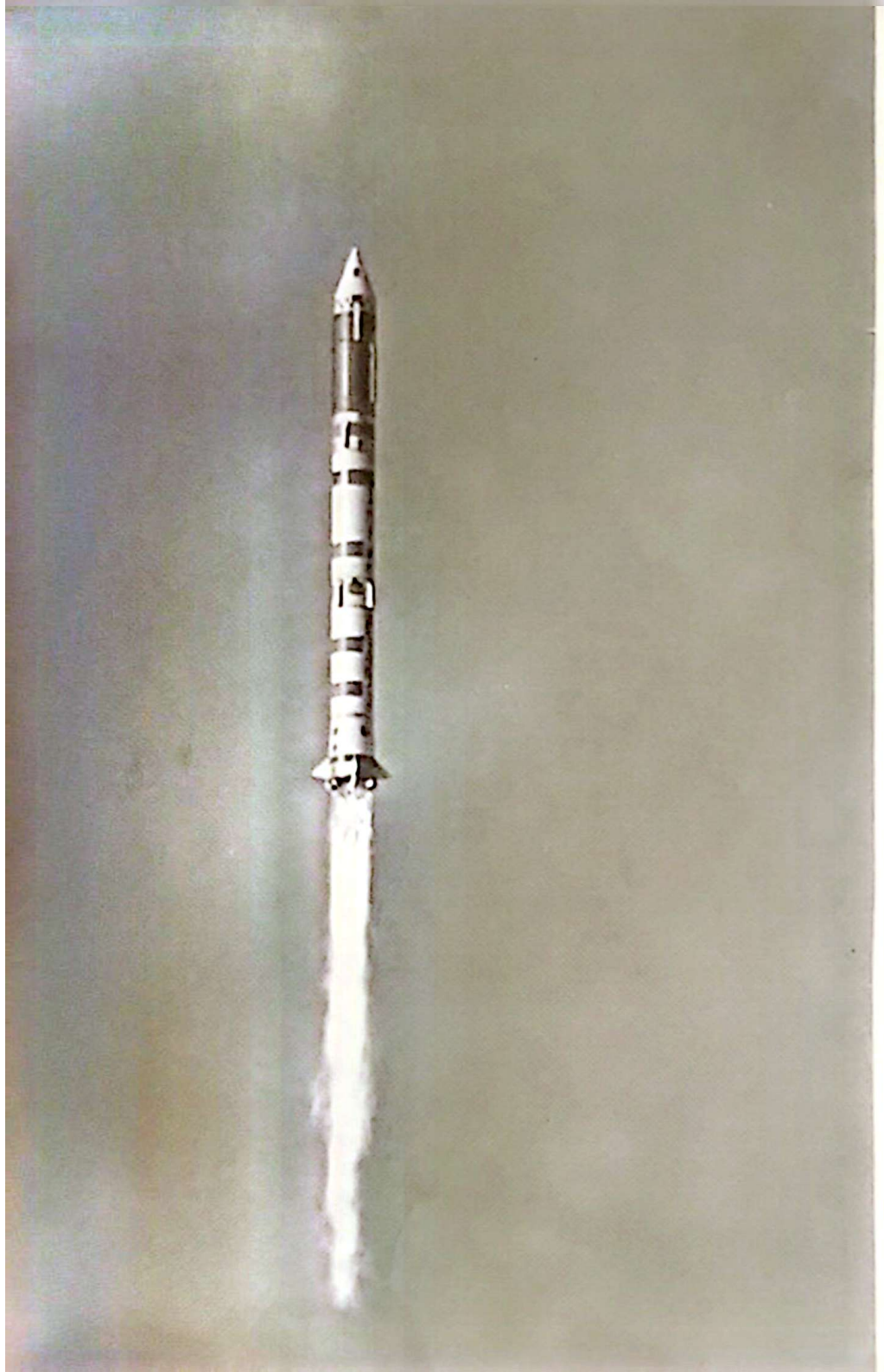
Only seven countries, namely the USSR, the USA, Britain, France, Japan, the People's Republic of China and India have developed rockets capable of orbiting satellites. And only two of them—the USSR and the USA—have the facilities for manned space flights. And this is quite understandable, for not every country has the means to run a specialised industry, cosmodromes, a global network of tracking stations and large-capacity computing centres. But today practically all the industrially developed countries are trying to explore space. The only sensible solution here would be large-scale international cooperation. The Soviet Union and other socialist countries have consistently called for broad cooperation in the space effort.

In October 1969 the artificial satellite *Interkosmos-1*—a product of the joint effort of ten socialist countries participating in the *Interkosmos* programme—was put into orbit. The programme has been making steady headway. In pursuit of this programme nine international manned space flights have been carried out, 21 *Interkosmos* satellites and ten *Vertikal* geophysical rockets have been launched, and major experiments have been conducted on the ground. The first *Interkosmos* satellites were fairly simple vehicles, but since 1976 all-purpose automatic orbital stations have been launched. The amount of research instruments and equipment they have on board has increased three or even four times as compared to the satellites of the first generation, and their service life has trebled.

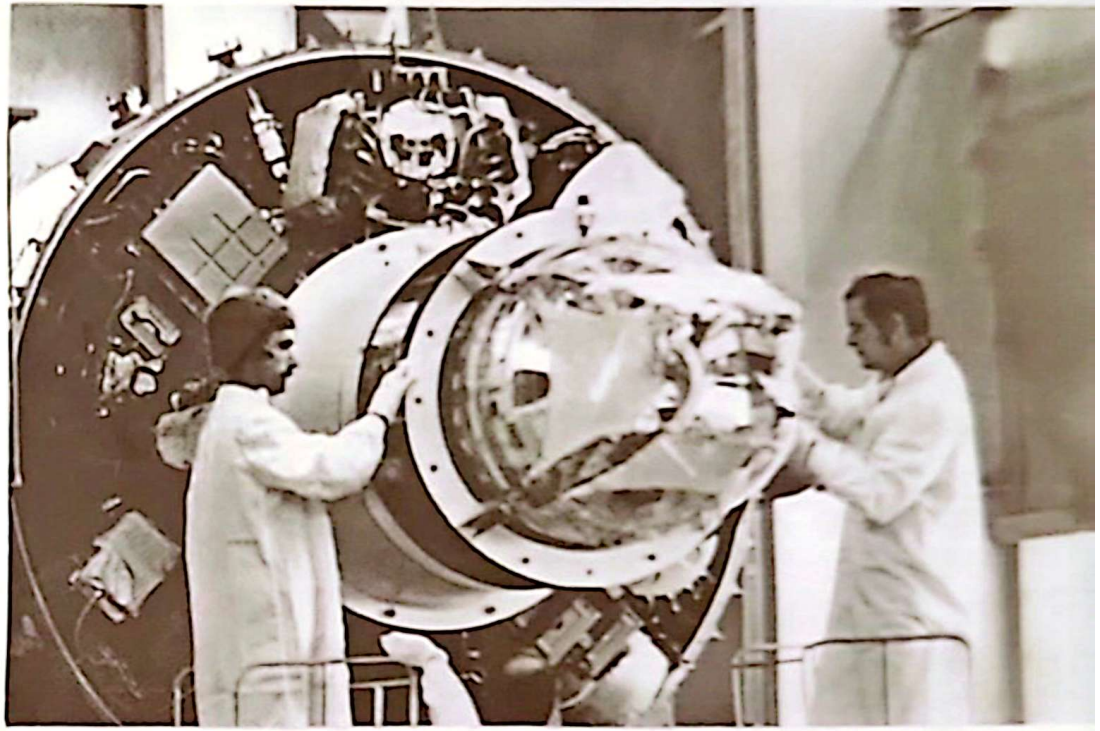
The success of international manned flights within the framework of the *Interkosmos* programme has kindled the interest of France and India. Some time ago the Soviet Union offered to train cosmonauts from these countries who will take part in future space expeditions.

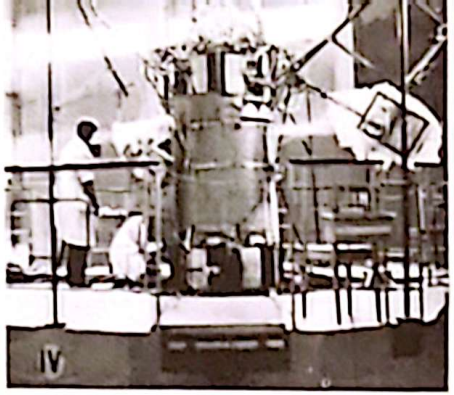
Soviet and French scientists have been engaged in joint research for over 15 years. They have sounded the atmosphere and magnetosphere.

More accurate measurements of the distance between the Earth and the Moon were made with the help of French-made corner reflectors mounted on two Soviet-made *Lunokhod* moon rovers. This was a major contribution to fundamental science. Since the early 1970s French instruments have been installed in Soviet *Prognoz* satellites and on board *Mars* and *Venera* automatic stations. Soviet rockets have been used for orbiting several French satellites. French scientists have been taking a most active part in inter-

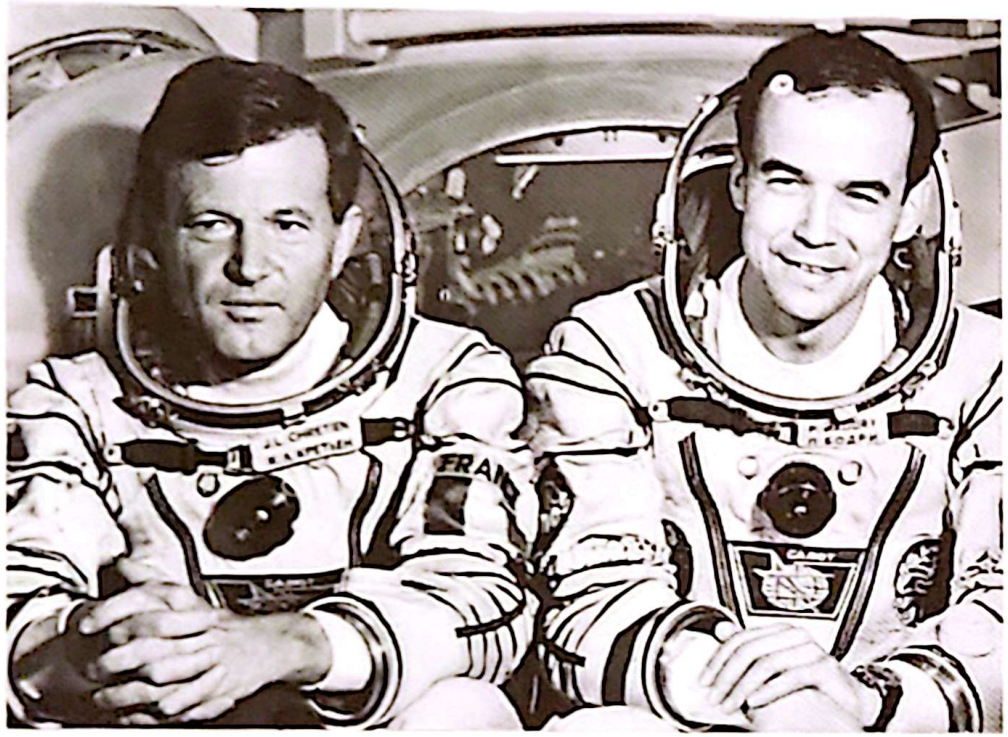


Preparations for launching the *Sneg-3* French-made satellite

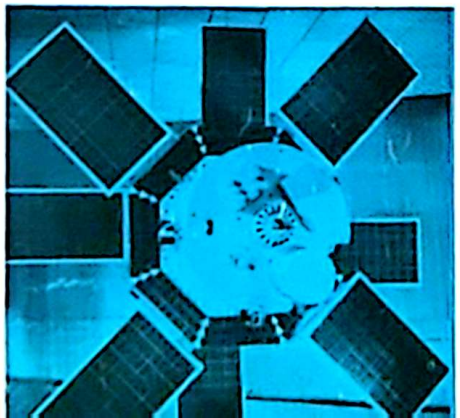




Preparing to launch the Soviet-French *Oreole* satellite



French pilots Jean-Loup Chretien and Patrick Baudry in the Cosmonauts' Training Centre



Interkosmos-1 satellite

national biological experiments conducted with the help of Soviet *Kosmos* satellites.

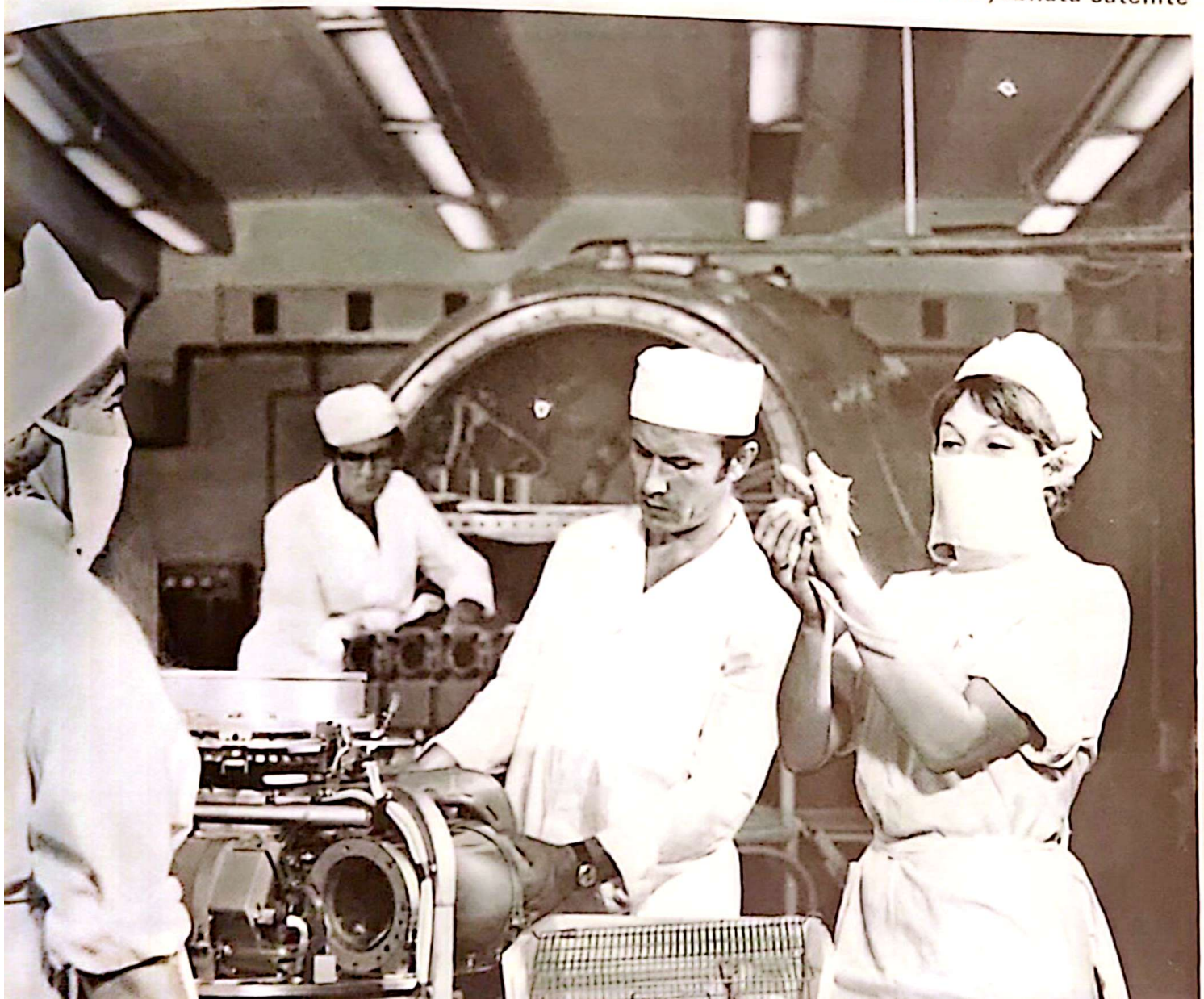
Soviet crews in *Salyut-6* conducted experiments in biology and space technology and processes jointly prepared by Soviet and French specialists.

Soviet-Indian cooperation in space research began in 1964. The Soviet Union helped India in the construction at Thumba of a weather rocket launching site, which is a part of a network of stations located along the so-called Eastern meridian. This network also includes the Soviet stations on Hayes Island in the Arctic, the Molodyozhnaya station in the Antarctic and the French station on Kerguelen Island. The results of observations are transmitted to international weather information collecting centres which relay them to all interested countries.

In April 1975 the first Indian satellite *Aryabhata* was launched from a Soviet cosmodrome. The joint work on this vehicle helped develop two other satellites—*Bhaskara-1* and *Bhaskara-2*, which made a major contribution to exploration of India's natural wealth.

Indian and Soviet specialists test the communications link with the *Aryabhata* satellite

Final check for the *Kosmos-936* international biological laboratory before orbiting



India's *Aryabhata* satellite

The Moon, Venus and Mars

Academician Sergei Korolyov once told a meeting of Moscow students: "We won't have to wait for you to fly to the Moon and some of the planets, but it will be for you to decide what you will do there." Some of those students are today engaged in design work, using computers and testing models of tomorrow's space vehicles

In 1959 the Soviet Union sent three automatic probes in the direction of the Moon. The last of these delivered photographs of the far side of the Earth's natural satellite.

The number of *Lunniks* (vehicles sent to the Moon) has now reached 29, including the *Lunokhod* moon rovers and return rockets which delivered moon soil to Earth. One might say that the surface of the Moon has been more thoroughly studied than that of the Earth.

Sooner or later mankind will begin to develop the resources of other planets. Exploration of the Moon has shown that it is more economical to study the natural resources of planets first with the help of automatic devices. And, of course, all the best elements that have been tested on automatic *Lunniks* will be used on future Mars and Venus rovers. As far as the Moon itself is concerned, it is unlikely that it will play the role of a gigantic geological museum. Scientists already see ways of making practical use of it.

Since the Moon has no atmosphere it receives as much solar energy as all the continents of the Earth. If it were possible to cover its surface with semiconducting photocells and to find a means of transmitting energy to Earth (for instance, with the help of directed radio beams), the Moon could be turned into a huge electric power station.

It would be possible to build on the Moon astronomical observatories, TV relay stations, plants for making semiconductor components and pharmaceutical factories.

The first Soviet space station *Venera-1* was launched in the direction of Venus in the early 1960s. The flight of the fourth Soviet station of that series was a major achievement in the study of Venus. *Venera-4* sent back data on the lower layers of the planet's atmosphere, and its descent module made a soft landing on Venus' surface for the first time in world practice. The flight put an end to a long-standing dispute about the atmosphere of Venus; it proved that the atmosphere was nearly totally made up of carbon dioxide.

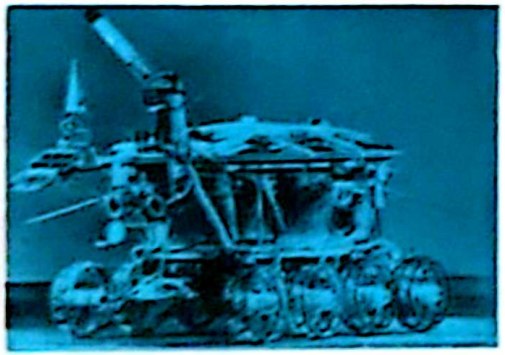
We now know that the temperature at the surface of Venus is about 500 degrees Centigrade and the atmospheric pressure is fantastically high—90 times higher than that on the Earth's surface. These important parameters were established by Soviet space research stations sent to that planet later.

The information obtained by *Venera-9* and *Venera-10* may indeed be considered sensational. In October 1975 photographs of Venus' surface were transmitted to the

Assembling the *Venera-12* space probe

Space probe for studying Mars

A sample of lunar soil



Lunokhod-1 moon rover

Salyut-Soyuz-Progress space complex at the USSR Exhibition of Economic Achievements in Moscow

Earth for the first time, showing plains and highlands strewn with boulders. Late in 1978 two more Soviet stations were sent to Venus. Besides confirming the earlier information they transmitted new data. It seems that, in contrast to the Moon and even Mars, man will have to surmount far greater obstacles to reach Venus. And so automatic devices will continue to work for some years on that planet. 1982 will mark a new stage in the exploration of Venus. Two more stations—*Venera-13* and *Venera-14*—have been sent to this planet.

The exploration of Mars has been equally exciting. Since the space age set in the Soviet Union has sent eight stations in the direction of Mars. The second of these has become an artificial satellite of that planet. It explored the planet from its orbit for a period of eight months. The descent module of the third station made a soft landing on the surface of Mars. Thus a highly difficult technical problem was solved.

Already the first findings showed that the climate on Mars is more "moderate" compared to that of Venus. In any case the temperature range does not differ very much from that on the Earth. However, the great disappointment is that the atmosphere of Mars is extremely rarefied. The pressure is 200 times lower than that of the Earth's atmosphere. This means that future explorers of Mars will have to wear pressurised suits. Mars has been studied more or less adequately. However, it is not yet known whether there is life on Mars.

Once at a meeting with students in Moscow Sergei Korolyov said: "We won't have to wait for you to fly to the Moon and some of the planets, but it will be for you to decide what you will do there." Yesterday's students are now working at drawing boards at design bureaus, doing calculations with the help of computers and testing at benches mock-ups of strange-looking machines of the near future. The study of space, which began brilliantly a quarter of a century ago, is proceeding along its course.

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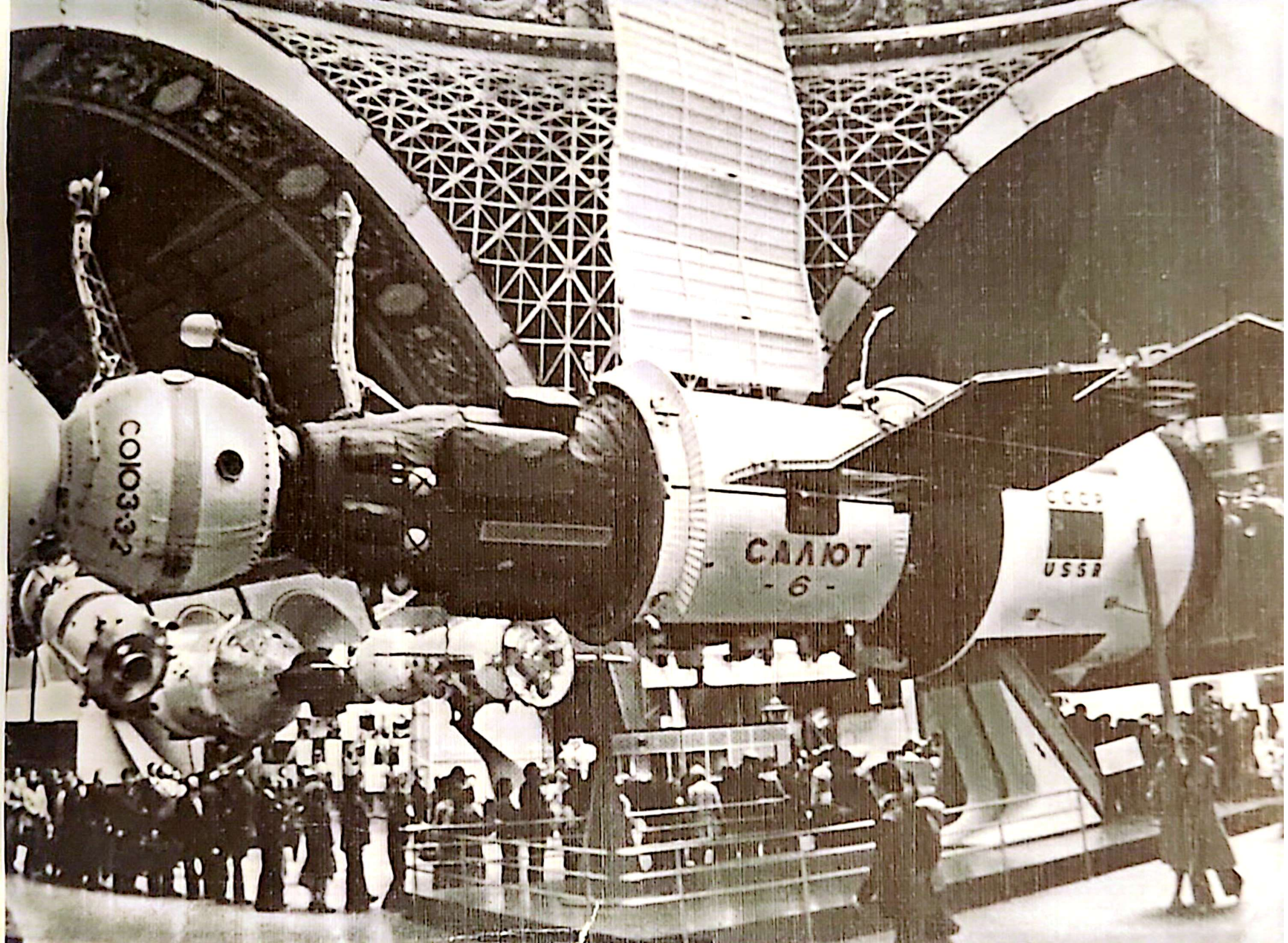
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